is just twice as long as I, the fringes will appear simultaneously on *both* upper surfaces, D and B.

The adjustment of the length of the standards is usually made to within a few waves, and the outstanding difference is measured by a compensating device.

This is furnished by the rotation of the compensating plate, G_2, Fig. 8. The plate is held in a metal frame which is supported at one end by a short thick rod firmly fixed to the bed. At the other end a delicate spiral spring is attached; the tension of the spring *twists* the rod through a minute angle, and thus alters the thickness of glass traversed by one of the interfering pencils. The other end of the spring is attached to a flexible cord passing over a pulley which is connected with a graduated circle. The angular motion is thus reduced about 100,000 times, and yet the proportionality is preserved.

Suppose the outstanding difference is ϵ a fraction of a wave-length known to within one or two tenths, then

$$II = 2I + \epsilon$$

and consequently the number of red waves should be $2 \times 1212{\cdot}34 + \epsilon$. This fraction is corrected by direct observation, as in the case of standard I, and the same control is furnished by the concordance of the results for the three colours; so that an error in the whole number of waves is well-nigh impossible.

The process of comparison and correction is repeated in the same way with the other standards, until we finally arrive at the whole number of waves and approximate fraction in the 10 centimetre standard. Up to this point the question of temperature and pressure is of minor importance, for the comparisons and corrections are made while both standards are under the same conditions; and being all made of the same material, it is sufficient to know that the temperature is the same for both. In the measurement of the fractions on the 10 centimetre standard, however, it is necessary to know the temperature and pressure with all possible accuracy, and it is also important that the comparison of this standard with the metre should be made, as nearly as may be, under the same conditions as that of the determination of the standard in light-waves.

The author having been honoured by an invitation from the International Bureau of Weights and Measures to undertake a series of experiments upon the lines here briefly indicated, the necessary apparatus was constructed in America, and shortly afterward installed in the Bureau International des Poids et Mesures at Sèvres.

Two complete and entirely independent determinations were made. These have not yet been completely reduced, but an approximate calculation gives for the number of waves of red light in one metre of air at 15° C. and 76 mm.

1st series	1553163·6
2nd series	1553164·6

The difference from the mean is half a wave, or about one fourth of a micron.[1]

From these results it follows that we have at hand a means of comparing the fundamental standard of length with a natural unit—the length of a light-wave—with about the same order of accuracy as is at present possible in the comparison of two metre bars.

This unit depends only on the properties of the vibrating atoms of the radiating substance, and of the luminiferous ether, and is probably one of the least changeable quantities in the material universe.

If, therefore, the metre and all its copies were lost or destroyed, they could be replaced by new ones, which would not differ from the originals more than do these among themselves. While such a simultaneous destruction is practically impossible, it is by no means sure that, notwithstanding all the elaborate precautions which have been taken to insure permanency, there may not be slow molecular changes going on in all the standards; changes which it would be impossible to detect except by some such method as that which is here presented

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[1] The error in the determination of the *relative* wave-lengths of the three radiations is very much smaller, probably less than one twenty-millionth.

FURTHER NOTES AND OBSERVATIONS UPON THE INSTINCTS OF SOME COMMON ENGLISH SPIDERS.

MANY of what would otherwise be most interesting anecdotes respecting the habits of spiders have been related by persons who, being unacquainted with the immense number of "kinds" of this group that there are in England, not to mention the rest of the world, have apparently considered that all needful information in the way of the animal's identity has been supplied by the simple statement that it is a spider.

Such anecdotes have of course a certain value, inasmuch as they furnish some general information respecting the instincts of the class as a whole. But to those who are anxious to compare together the instincts of individuals of the same or different species, genera, and families, who are anxious to acquire in short some little knowledge of the comparative psychology of the group, they are distressingly incomplete.

To remedy in part these deficiencies, to verify the experiments of others, and to make fresh observations upon some points that are open to dispute, I took the opportunity, during a recent visit to North Cornwall, of compiling a set of notes upon the habits of some of the commonest spiders in the neighbourhood.

In the following paper, which is based upon these notes, I have added some brief accounts of the webs, habitats, or general appearance of the spiders, so that those persons who are not acquainted with the animal by name, may yet, with but little trouble, ascertain what the species are that are under discussion.

Agalena labyrinthica.—This spider may be looked upon as the country cousin of the common house spider, *Tegenaria atrica*, which being essentially a lover of bricks and mortar, is found in lofts, disused rooms, &c., where it spins in corners and other angles a horizontal, triangular sheet of web, a familiar structure which must be associated in all minds with the word cobweb.

The snares of *Agalena* are essentially like those of *Tegenaria*, consisting of a short silken tube or funnel, one end of which is buried in the bush that the spider has chosen to build in, while the other opens upon, and is continuous with, a widely extended horizontal sheet composed of fine closely woven silken threads. During the daytime the spider, if cautiously approached, may usually be seen squatting at the entrance of her funnel. She is, however, remarkably wary, and this, coupled with her equally remarkable agility, makes the task of capturing her by no means an easy one. For, by means of the further open extremity of the tube, she can make her escape into the bush beyond. Wherever I have had an opportunity of observing this spider, I have noticed that it appears to have a special liking for furze bushes; and it seems reasonable to suppose that this selection of so prickly a site for the building saves the young and also the nest from destruction at the hands, or rather the noses and legs, of cattle.

Upon examining the *débris* of prey, with which the orifice of the funnel was usually strewn, I was surprised to find that it consisted more often of the remains of bees than of flies—generally, indeed, the limbs, wings, &c., were those of some species of Bumble-bees (*Bombus*). Being curious to see how the spider would manœuvre to overcome so redoubtable an adversary, I captured upon one occasion a small specimen of a bumble-bee and placed it upon the snare. The *Agalena* immediately darted forth; but upon touching the insect with her fore-legs, quickly drew back as if to keep out of harm's way. Meanwhile, the bee, by making vigorous efforts to escape, had nearly succeeded in breaking away the web with which its legs were entangled—a fact of which the spider seemed well aware. For, rushing at it once more, she rapidly, and, by some dexterous movement that I could not follow, attached a thread either to the insect or to a portion of the web hard by, and then started to run rapidly round and round her prey, letting out the thread as she went, and literally winding the insect up. Having by this safe and satisfactory process speedily put a stop to all immediate likelihood of escape, and having also achieved the desired end of hampering the bee's movements, she again rushed two or three times at it, although still evidently bearing in mind the desirability of not coming to close quarters, and ultimately succeeded in inflicting a bite on one of its legs. From that moment all anxiety on her part respecting the probability of the escape of her prey seemed to disappear, for instead of keeping madly on the move, as she had done up to the time of dealing the wound, she quietly retreated to her funnel and sat down to wait. Nor was an explanation of this behaviour long in presenting itself. For the bee's struggles became more and more feeble, and in about one minute ceased altogether. There was very little doubt in my mind that this was attributable to poisoning; but to make sure that its quiescence was not due to exhaustion from its efforts, I took it from the web for examination, and found that it was to all intents and purposes dead, the only perceptible movement that it made being a slight twitching of the extremities of the antennæ. Whilst I was examining it I noticed the *Agalena* issue from her funnel and return to the spot where she had left her victim.

Subsequently to discover to what extent the spider's behaviour on this occasion was to be explained by her knowledge of the formidable nature of the bee, I placed a blue-bottle fly in the web of another specimen. The spider immediately rushed out, touched the insect with her fore-feet, and falling upon it without further delay, dragged it to the entrance of her tube, and proceeded to devour it.

As a further experiment I introduced an example of the drone-fly (*Eristalis*) into the web of a third example of this species; but, curiously enough, instead of instantly slaughtering the harmless insect, as the second one had the blue-bottle fly, this spider treated it with the same caution that the first had shown towards the bee. She did not, however, wind it up, but, keeping at a respectful distance, and watching for an opportunity, she ultimately bit it in the foot and killed it by this means in a few moments.

From these observations I think three conclusions may be legitimately drawn:—(1) That the first spider avoided contact with the bee for fear of being stung; (2) that the other mistook the *Eristalis* for a bee, as ninety-nine uninitiated human beings out of a hundred would also do; and (3) that the spider's bite rapidly compassed the death of the insects owing to the injection of poison. I wish to draw special attention to this last conclusion, not but that the others are more interesting, because Dr. McCook, when recently investigating the question of spider-venom, was inclined to reject the conclusion that the mandibular fluid of these Arthropods possesses any poisonous property.

His suggestion that the death of an insect results from mutilation caused by the bite clearly will not apply in the present instances where only a leg was bitten. For myself, I do not doubt that the fluid in question is poisonous, although probably in a varying degree to the insects upon which the spiders prey, and that the use of the poison is—as it also is, I think, in the case of scorpions—to put a speedy end to struggles, so as firstly to remove all chance of escape on the part of the prey, and secondly to lessen the probability of injury being done to the Arachnoid by a captive which might also be armed with jaws or stings.

When watching a couple of *Agalenas* pairing I was much struck by the extreme pertinacity with which the operation was carried on. As above stated, specimens of this species are usually exceedingly shy and very difficult to approach, but at this period both male and female seemed utterly oblivious to all their surroundings. They even permitted me to tear away portions of the web, and even to touch them without flinching. A cloud of tobacco smoke made them separate for a short time, but no sooner had it dispersed than they resumed operations as before. I repeatedly pulled the male from the female with my forceps; whereupon she would in alarm retreat to the further extremity of her tube, but he, seemingly, very little disconcerted by the compulsory interruption, would, when placed again in the web, quickly follow her, and presently both would appear again at the entrance of the tube, she lying perfectly passive and he hoisting her along with the patellæ of a pair of her legs grasped in his mandibles. Nor was she apparently much less eager than he, for on two occasions, when he was a little longer than usual in following her, she came forth herself apparently in search of him. It was noticeable that they invariably took up the same position in the same spot at the entrance of the tube, the female lying on her right side with her head towards the posterior extremity of the tube, the male standing over her facing the opposite way. A sketch made of them in this position agrees almost exactly with a figure that Dr. McCook has given of the attitude assumed under similar circumstances of the North American species, *Agalena nævia*. When I left this interesting couple the female had retired to the back of the tube, while the male sat on guard at the entrance. I say on guard, because when touched with my forceps he, instead of running away, raised high his forelegs, striking the instrument with them, and snapping at it with his mandibles. The way in which all the instincts for the preservation of the individual were overridden in this instance by the instinct for the preservation of the race brought very vividly before me the force of Prof. Lloyd Morgan's happy paraphrase of Shakespeare—"To breed or not to breed, that is the question."

Amaurobius similis.—This spider is very common in Cornwall, as elsewhere. It belongs to the same great group of tube-weavers as *Agalena*, spinning a tubular web in ivy, holes in walls, &c., and surrounding the aperture with a tissue of irregularly interlacing somewhat loosely woven threads which present a white thickened appearance, owing to the presence of flocculent tufts of silk that are produced by the agency of those interesting spinning organs, the *cribellum* and *calamistrum*. Like *Agalena* and *Tegenaria*, *Amaurobius* runs with agility on the upper surface of its web. *A. similis* is much smaller than *Agalena labyrinthica*, but does not appear to be so timid. I could never be sure of attracting *Agalena* to a vibrating tuning-fork, but *Amaurobius* would always come and even climb along the instrument. I have enticed this species from its hole by holding the vibrating-fork near the aperture, although not in contact with any part of the web. And all the specimens that were noticed on the external sheet of the web responded invariably when the vibrating-fork was held above them at a distance of about half an inch. But instead of running away from the instrument, or reaching up at it as the *Epeiridæ* do, *Amaurobius* moved excitedly about, apparently searching for the cause of the vibration. One specimen while thus searching came across and instantly seized the old dried-up carcase of a blue-bottle fly, as if perfectly satisfied with the result of its investigation. Another example, discovered away from her web, made no response whatever when the fork was held close to her back. This circumstance, coupled with the fact that no specimen of this spider ever gave the smallest sign of knowing the direction whence the sound proceeded unless its web was actually touched with the tuning-fork, is in favour of Dr. McCook's view, that the *Epeiridæ*, which respond readily to a tuning-fork that is held near them, are only aware of the proximity of the vibrating instrument through the responsive vibration of the web. This may be the true explanation with regard to *Amaurobius*, but there are several reasons, as will shortly be seen, which lead me to think it is not so where the *Epeiridæ* are concerned.

Pholcus phalangioides, belonging to a group by itself, is a common spider in many parts of the south of England. It frequents kitchens and outhouses, where it spins a very untidy-looking web, composed of irregularly interlacing loosely-woven threads. The species cannot be readily mistaken for any other true British spider, on account of the extreme length and thinness of its legs. Owing to this peculiarity, it is probably largely responsible for the popular but erroneous idea that the Opiliones—the harvest-men or long-legged spiders *par excellence*—can spin webs. Whenever any part of the web of a *Pholcus* was touched with a vibrating tuning-fork, the occupant would come clumsily and leisurely up to the instrument, and when it was held close to the back of the spider, the latter would show its perception of the vibration by slowly lifting its legs. One specimen away from its web responded in exactly the same manner as the others did when hanging in the midst of their snares, thus showing that it is not the vibration of the web that informs this species of the proximity of the instrument.

Epeira diademata, *Meta segmentata*, and *Zilla x-notata*, are three very common spiders belonging to the group of Orb-weavers. The first-named—the common garden or cross-spider of England, one of the largest of our species—is known to every one. *Meta segmentata*, too, is very abundant, spinning its web in hedges and bushes; it may be easily recognised from *E. diademata* by its much smaller size and more graceful build. *Zilla* is more like *Meta* than *Epeira*, being a smallish, rather graceful species, which spins its web very commonly in the angles of windows, &c. The structure of its web also affords another clue to its identity, for while in *Epeira* and *Meta* the snare is a complete orb, the concentric lines extending across all the radii from the centre to the circumference, in *Zilla*, as a very general rule, two of the interradial spaces in the upper half of the web are not crossed by the concentrices: the circle of the web thus lacks one sector, and the resulting triangular space is traversed by a free radius which is continued beyond the circumference of the snare, and connects its centre with a second small irregular web, which is spun in a crevice or beneath some leaf.

Like most other spiders these three species will usually come to a vibrating tuning-fork, if the web be touched with it. And if it be held over the centre of the web where the spider is hanging, the three will readily respond to the sound; but not in the same way. As Mr. and Mrs. Peckham and Prof. Boys[1] have shown, an adult *Epeira diademata* raises its forelegs and snatches at the instrument, while *Meta*[2] *segmentata* instantly drops by a thread from her snare; but *Zilla*, so far as my experience goes, instead of dropping like *Meta*, nearly always climbs quickly along the free radius back to the upper web. One example, however, repeatedly dropped from its web, and two others, one adult and one young, moved excitedly about as if in search of the cause of the sound, exactly as described in the case of *Amaurobius*. Curiously enough the sound affects the examples of *diademata* differently according to their age. Thus quite small examples drop by a thread, but half-grown examples either drop as the young do, or strike at the fork like the adults. It appears therefore from these facts, that as a general rule the small English Epeiridæ fear the sound of a vibrating tuning-fork, while the large ones do not. What is the explanation of this? Prof. Boys, who has previously noticed this same fact in connection with *E. diademata* and *Meta*, thinks that it is perhaps to be explained on the grounds that the vibrating tuning-fork is mistaken for an approaching wasp—an insect which, to use Dr. McCook's words, "is the most persistent enemy of spiders." But a full-grown *E. diademata* is too formidable an opponent for a wasp to attack, and it seems well aware that anything buzzing can be overcome and eaten, or at least repulsed. Not so, however, is it with a *Meta*. A wasp can take one of these small spiders out of its snare while still on the wing, and the spider's life depends upon the quickness with which it can perceive the approach of its enemy and act upon the perception by dropping out of harm's way.

This ingenious suggestion is further borne out by the behaviour of *Zilla* and of the young *diadematas*, for these spiders would have no more chance against a wasp than *Meta* has. Moreover, my friend Mr. Henderson, of Madras, has informed me that he has repeatedly seen examples of a common Indian house spider[1] drop from their webs at the approach of the mason-wasps.

Such a habit, then, of falling or running away would clearly give a spider that possessed it an advantage in life over others of the species in which it was not developed, and the elimination of the latter and the survival of the former, with the consequent chance of breeding, would foster the habit and bring it to the state of perfection in which we now see it.

On the other hand, the loss of the habit in the adult *E. diademata*, may perhaps be explained on the hypothesis that the act of dropping entails the expenditure of energy in the form of waste of silk and of muscular tissue; moreover, it might at the same time on occasions lead to the escape of an insect that would have served for prey if the spider had remained in *statu quo*. The two instincts are seen in a state of transition in half-grown *diadematas*. But the acquired one of fearlessly fighting the enemy would be prevented from appearing too early in life by the destruction of those individuals which, with over-confidence on their growing powers, stayed in the web when they ought to have dropped from it; or, in other words, the runaway instinct would be preserved as long as the spider was too small to cope with a wasp.

Another interesting question connected with this behaviour of the Epeiridæ is the means whereby the vibration of the fork is perceived. The obvious answer is that the sound is heard. But Dr. McCook has recently objected to this explanation on the grounds that the Lycosidæ, which spin no web, and which, in Dr. McCook's opinion, have more need of an auditory sense than the Epeiridæ, make no response when the vibration is brought near them.

It has been objected (*Ann. Mag. Nat. Hist.* Ser. 6, viii. p. 103), however, to this opinion of McCook's that the Epeiridæ which spin their webs in places where flies are likely to be caught, must of necessity at the same time expose themselves to the attacks of wasps. We can therefore imagine that it is of the highest importance to them to be able to perceive the approach of their enemy—of more importance to them, in fact, than to those spiders, which like the Lycosidæ spin no exposed and conspicuous snare, and are therefore more likely to escape the notice of the wasps.

To account for the behaviour of the Epeiridæ when a vibrating fork is brought near them, Dr. McCook has suggested that the vibration of the instrument causes the threads of the web to vibrate in turn, and that the spider is informed of the nearness of the instrument by the delicate sense of touch in the feet. But so far as my experience goes this hypothesis is not sufficient to account for the facts; for it is difficult to understand how the sense of touch in the feet can merely by being in contact with the threads, which by hypothesis are in a state of vibration, inform the spiders of the position of the fork and of the direction whence the sound proceeds. For of this, to judge by their actions, they appear to have a full knowledge. For instance, one adult example of *E. diademata* that I observed, responded in the manner above described when the fork was held over her back; but when the instrument was brought towards her ventral surface on the other side of the web she drew her body away from it, standing as it were on the tips of her toes. Again, when the fork was brought from below to within a distance of an inch and a half or two inches of a *Meta* suspended by a thread from her web, she instantly dropped again. In this case it is hard to believe that from such a position the fork could throw the web into a state of vibration. On the other hand, no example of the Epeiridæ could ever be attracted along one of the radii of the web, however close the fork was held to it, unless the two were actually in contact. In view of these facts, it seems to me probable that Mr. and Mrs. Peckham's explanation of the behaviour of the Epeiridæ—namely, that they hear the vibration—is the true one.

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[1] NATURE, vol. xliii. pp. 40-41.

[2] This is probably the small unidentified orbicular spider that Prof. Boys speaks of.

[1] Mr. Henderson kindly procured examples of this spider for me, and they proved to belong to the genus *Pholcus*.

R. I. POCOCK.

NOTES.

THE Royal Society's medals have this year been adjudicated by the President and Council as follows:—The Copley Medal to Sir George Gabriel Stokes, Bart., F.R.S., for his researches and discoveries in physical science; a Royal Medal to Prof. Arthur Schuster, F.R.S., for his spectroscopic researches, and his researches on disruptive discharge through gases and on terrestrial magnetism; a Royal Medal to Prof. Harry Marshall Ward, F.R.S., for his researches into the life history of fungi and schizomycetes; and the Davy Medal to Messrs. J. H. van't Hoff and J. A. Le Bel, in recognition of their introduction of the theory of asymmetric carbon, and its use in explaining the constitution of optically active carbon compounds. Her Majesty the Queen has been graciously pleased to approve of the award of the Royal Medals. The medals will, as usual, be presented at the anniversary meeting on St. Andrew's Day (November 30). M. Le Bel has promised to attend in person, and it is hoped that all the medallists will be present. The Society will dine together at the Whitehall Rooms on the evening of the same day.

BY the death of Sir Andrew Clark, on the 6th inst., the medical profession has lost one of its most prominent members. The Royal College of Physicians has to mourn the decease of its President, and, outside the faculty, a large and distinguished section of the community is affected by it. Sir Andrew was born on October 28, 1826, at Aberdeen, and pursued his medical career there and at Edinburgh. Subsequently he entered the Royal Navy as a surgeon, and, after making a few voyages, became pathologist to the Royal Naval Hospital at Haslar. There he met Prof. Huxley, who was then professor of biology at the hospital school. In 1853 he accepted the curatorship to the museum of the London Hospital, and was afterwards appointed pathologist to the hospital, then lecturer on physiology, and in 1866 full physician. After this Sir Andrew rapidly came to the front, and from the first his connection was composed largely of men distinguished in science, art, and literature. In 1883 Her Majesty recognised his position in the profession, and his services to medical science, by conferring upon him the honour and title of a baronetcy. Five years later he was elected to succeed Sir William Jenner as President of the Royal College of Physicians, an honour that he valued even more highly than Royal favours. He was a Fellow of the Royal Society, an LL.D. of Aberdeen, Cambridge, and Edinburgh, and honorary M.D. of Dublin. The respect in which he was held is shown by the influential and representative character of the assembly at a commemorative service in Westminster Abbey on Saturday. The pall-bearers included the Prime Minister, Sir Henry Acland (Regius Professor of Medicine at Oxford), Sir James Paget (Vice-Chancellor of London University), Mr. John Whitaker Hulke (President of the Royal College of Surgeons), Sir Richard Quain (President of the General Medical Council, representing by request of the Provost the University of Dublin), and Sir Edward Sieveking. Following these, with the officers of the Royal College of Physicians, came representatives of the Universities, State departments, and various institutions. Prof. Clifford Allbutt attended for Cambridge, Sir Joseph Fayrer for Edinburgh, Dr. Farquharson, M.P., for Aberdeen, Mr. J. N. Dick for the Navy Medical Department, Sir William Mackinnon for the Army Medical Department, Dr. Thorne Thorne for the Medical Department of the Local Government Board, Sir William Flower for the British Museum, and Prof. Michael Foster for the Royal Society. Among the large congregation were Prof. Huxley, Sir Spencer Wells, and Sir Walter Phillimore. Honoured in life, Sir Andrew Clark's memory will be cherished by all acquainted with his wonderful energy, devotion to duty, and self-sacrifice—attributes worthy of emulation by all followers of his noble profession.

THE death of Dr. H. A. Hagen, a well-known entomologist is announced from New York. He was born in Königsberg in 1817, and became an assistant to Agassiz in 1867. Three years later he was appointed Professor of Entomology at Harvard College. It can truly be said that his works furnish a monument to his memory, for he made more than four hundred contributions to scientific literature.

WE have to record that Mr. A. Reckenzaun died on November 11, at the age of forty-three. His name is familiar in connection with papers on accumulators, electric traction, and electric locomotives, for certain of which he was awarded medals by the Society of Arts and the Institution of Electrical Engineers.

WE regret to learn from Sydney of the death of Dr. George Bennett, a distinguished naturalist, and the author of "Wanderings in New South Wales" and other works. He was ninety years of age.

THE death is announced of Mr. J. G. Barford, the author of a number of papers on physiological chemistry.

IN January next, the Botanical Society of Italy will take over the *Nuovo Giornale Botanico Italiano*, at present edited by Prof. T. Carnel, and publish it as the official organ of the Society. No modifications will be made, however, in the character of the journal, which will continue to be issued in quarterly numbers.

A meeting of representatives of technical schools was held at Manchester on the 4th inst., and it was resolved "that it is desirable that an Association of Technical Institutions be formed." With a view to formally constituting the proposed Association, a meeting will be held at the Society of Arts, on Friday, January 26, 1894.

THE new institute of science, art, and literature, established by the corporation of Carlisle at a cost of about £20,000, was opened by the mayor of that city on November 8. The institute includes a museum, a school of science and art, and a free library. In addition to a valuable collection of antiquities, the